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High-Energy X-ray Scattering Studies of Orbital Ordering in $Pr_{1-x}Ca_xMnO_3$

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Beamline(s): X22A

The complicated charge and orbital ordering—as well as its destruction upon application of a magnetic field, pressure, or an intense beam of photons—exhibited by $Pr_{1-x}Ca_xMnO_3$, $0.3 \leq x \leq 0.7$, reflects the delicate balance between kinetic, Coulombic, superexchange, and lattice energies in this material. Recent studies of the ordering have focused on its melting, and a commensurate-incommensurate transition has been reported.[1-4] Above the transition, though, conflicting accounts of step-like[1,2] versus continuous[3,4] changes in the incommensurability have made it difficult to understand the evolution of the ordering near the transition temperature. Therefore we have carried out an investigation of the lattice distortions associated with orbital ordering using high-energy x-ray scattering techniques. With the incident photon energy set to 32 keV, we measured the ordering wavevector as a function of temperature in $Pr_{1-x}Ca_xMnO_3$, x = 0.4 and 0.5 (see below for results from studies of the x = 0.4 sample). Intriguingly, we observed continuous—yet opposite—behaviors of the longitudinal and transverse incommensurabilities, which we believe to be related to the balancing of the energy cost of domain walls and the strain energy caused by the presence of charge and orbital ordering.[5]

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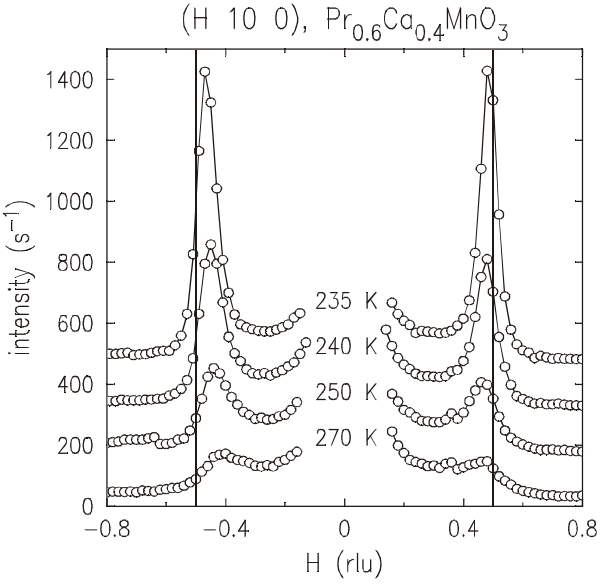

Figure: Temperature dependence of satellites—associated with the presence of orbital ordering—near the (0 10 0) Bragg peak in $Pr_{0.6}Ca_{0.4}MnO_3$. The lines at H = ±0.5 indicate the commensurate positions of the peaks at temperatures below ~210 K